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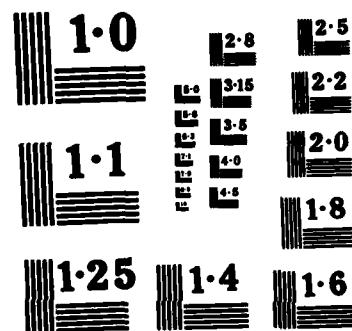
WITHIN-PERSON COVARIATION BETWEEN MOOD AND BIOCHEMICALS 1/1
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WITHIN-PERSON COVARIATION BETWEEN MOOD AND BIOCHEMICALS

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REPORT NO. 80-20

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WITHIN-PERSON COVARIATION BETWEEN MOOD AND BIOCHEMICALS*

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ABSTRACT

A presumed covariation of mood and biochemicals is important in models of stress and emotion. A within-person approach should yield a sensitive test of this hypothesis, but prior studies of routine life situations had shown only modest associations. The present study applied the within-person approach to 34 men with variation in stress known to be sufficient to change mood and biochemical variables. Average within-person correlations were strong for moods and small, but frequently significant, for biochemical variables and mood-biochemical pairs. Significant inter-individual differences in the correlations were present for moods and possibly for mood-biochemical pairs. These results were consistent with current theories of emotion given peripheral biochemical measures. The cumulative effects of the mood-biochemical associations may be significant for behavior and health, because moods were related to a number of relatively independent biochemical parameters. Because important inter-individual differences in within-person correlations are still a possibility, the hypothesis of strong mood-biochemical variable covariation may apply to some people.

Keywords:

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INTRODUCTION

It is commonly assumed that human emotional experiences are accompanied by physiological arousal (cf., Levi, 1975). This assumption is important to stress research as a potential link between psychosocial stimuli and illness (e.g., Rahe & Arthur, 1978). Stress research also posits that different individuals can employ different coping and defense mechanisms which can reduce the correspondence between mood and physiological arousal (e.g., Weinstein, Averill, Opton & Lazarus, 1968). Hypothetically, certain defense mechanisms may also increase the correlation between the two (Vickers, 1979), but in either case, the association between variations in mood and variations in biochemical parameters will vary across individuals. The present study used a longitudinal research design to determine within-person correlations of moods and biochemical variables to establish the strength of the average covariation and the consistency of the relationship across people.

The use of a within-person design is less common than the standard between-persons approach. The within-person approach can provide more meaningful tests of psychosomatic hypotheses (Mefferd, 1966) and avoids confounding chronic interindividual differences in mean biochemical levels (e.g., differences due to genetic factors) with biochemical responses to a given situation (Kraemer, Note 1). Previous applications of this approach have shown little association between mood and biochemical variability (Doering, Brodie, Kraemer, Moos, Becker & Hamburg, 1975; Houser, 1978), but this may have been due to studying situations with modest variation in stress levels.

The present study involved repeated measures of mood and biochemical variables for men performing a job with a known pattern of variation from high to

low stress (Ward, Rahe, Conway, et al., Note 2). The variation in stress has been shown to be sufficient to produce significant variations in the men's moods and biochemical variables (Ward, Rahe, Conway, et al., Note 2; Rahe, Conway, Vickers, et al., Note 3). The job situation was sufficiently important and ambiguous to allow coping and defense mechanisms to operate. These conditions are important if individual differences in within-person correlations depend on individual differences in defense and coping mechanisms (Erickson & Pierce, 1968; Lazarus, 1966). Finally, the study included multiple measures of each of several moods and several biochemical variables. Multiple measures should reduce the possibility of falsely concluding that no important associations exist due simply to sampling the wrong combination of measures. At the same time, multiple measures provided an opportunity to test a secondary hypothesis of mood-biochemical specificity. Hypotheses that stipulate possible one-to-one relationships between moods and biochemical variables are sometimes suggested as a means for understanding the development of specific psychosomatic illnesses (e.g., Henry & Stephens, 1977), so the possibility that changes in a given biochemical variable might be linked to changes in only a single mood was of interest.

METHODS

Sample

Participants in this study were 34 senior U.S. Navy Petty Officers assigned to duty as company commanders and responsible for the basic training of Navy recruits. Sixty-four men initially volunteered to participate in the study, but nine did not complete Company Commander School for administrative reasons and another nine had difficulty during their initial exposure to training recruits.

An additional 12 only participated in the study for the first 8 data collection points. These were excluded from the present analyses because of the limited number of data points for determining covariation of mood and biochemicals.

The 34 men studied here successfully trained two companies of recruits. The average company commander in this group was 33 ± 4.2 years old, had 12.1 ± 1.1 years of education, and 13.6 ± 4.4 years of active military service. Twenty-six were Caucasians, five were Blacks, and three were of other racial origins. Twenty-eight were married, one was separated, three were divorced, and two had never been married. The group of 34 was not different from the men who did not participate for the full length of the study on any of these variables.

Study Days

Data were collected on 14 study days distributed over approximately an eight-month period. During this period, participants attended six weeks of Company Commander School (CCS), were "on hold" an average of 46 days before being assigned their first recruit company, trained their first company during the next nine weeks, had a break of approximately 30 days, then trained their second company. The 14 study days coincided with the first and last days of CCS and six equivalent days during each of the two recruit training cycles. A more detailed description of the study days is provided in an introductory paper describing the overall study objectives, research design, and measures for the study (Ward, Rahe, Conway, et al., Note 2). Analysis of subjective stress indicators reported in that paper showed that perceptions of stress

varied significantly across study days, that there were at least two distinct levels of stress, and that the pattern of stress variation across the study days was the same during each of the two training cycles studied.

Mood Measures

Moods were measured using the Mood Questionnaire (MQ; Ryman, Biersner & La Rocco, 1974). The MQ contains 40 adjectives for which respondents indicated whether they felt "not at all" (1), "somewhat or slightly" (2), or "mostly or generally" (3) as described by the adjective. Unweighted responses were summed to create scales for Activity, Anger, Depression, Fatigue, Fear, and Happiness. The MQ was administered on all study days.

Biochemical Variables

A single blood sample was collected from each participant on all study days. Most blood samples were collected during the morning, but the specific timing of the sample had to be fitted to the study participant's schedule for the day. Serum was extracted and determinations were made for the following constituents:

1. Cortisol: This hormone was measured by a radioimmunoassay using the method and antibody (anticortisol-21-thyroglobulin) of Miles Research Products. (1,2,6,7-H) cortisol (82 curies per millimole) was purchased from Amersham Corporation. All samples for a given man were run in the same assay.
11. Testosterone: This hormone was measured using the method described by Odell, Swerdloff, Bain, et al. (1974) with one modification: the preparatory column chromatographic step was not performed so both testosterone and dihydrotestosterone were measured. All samples from a given man were run in the same assay.

- iii. Cholesterol: Total serum cholesterol was measured by adding 0.013 milliliters of serum to 1.30 milliliters of "A-Gent" cholesterol reagent (Abbott Laboratories). Incubation was described by Abbott, and absorbance of standards and tests was measured at 500 nanometers.
- iv. Uric Acid: Phosphotungstate reagent (American Monitor) with a uricase-treated blank for each test was used to measure uric acid. The procedure followed was that described by the American Monitor, except that volumes were reduced to 50 percent of those given (0.050 milliliters of serum were used). Absorbance was measured at 750 nanometers.
- v. Dopamine-Beta-Hydroxylase: This enzyme was measured using the procedure of Nagatsu and Udenfriend (1972) with a minor modification which will be described in a future report. Absorbance was read at 330 nanometers.
- vi. Pepsinogen I: The concentration of pepsinogen I was determined by a competitive binding, double antibody radioimmunoassay, as described by Samloff and Liebman (1974). The standard used in this study was isolated from human gastric mucosa and was 1.75 times more immunoreactive than the original standard isolated from urine. Consequently, the normal range, previously 50 to 175 nanograms per milliliter, was 28 to 100 nanograms per milliliter.

Analysis Procedures

Pearson product-moment correlations were computed for each man using the 14 paired observations for each combination of measures. Mean correlations were

determined for the sample using Fisher's r to z transformation (McNemar, 1969, pp. 151-159). The significance of the mean correlation was determined by a t-test on the z-transformed correlations. Hays' (1963, p. 532) Y statistic was used to determine whether there was significant heterogeneity among the within-person correlations. A binomial test with $p = .05$ was used to determine whether the number of individuals showing significant ($p < .05$) within-person correlations was greater than would be expected by chance. To allow for the possible effects of serial correlation on these computations, Quenouille's procedure (cf., Holtzman, 1963, p. 207) was used to estimate the effective degrees of freedom for the Y statistics and the within-person correlations. The application of this procedure employed the standardized within-person scores which were the basis for the within-person computations.

Results are presented separately for the correlations among the moods, among the biochemical variables, and between the two. In addition to the standard 5 percent significance level, tables report two significance tests based on a Dunn-Bonferroni adjustment to allow for multiple significance tests (Dunn, 1958). The first considers each variable in a table separately, e.g., considers only the correlations for anger. The second considers all of the correlations reported in the table simultaneously. In each case, the adjusted significance level guarantees an overall Type I error rate of less than 5 percent given the number of tests performed. Because there are correlations among the moods and among biochemical variables, the individual significance tests are not completely independent and the Dunn-Bonferroni procedure is conservative; the true experiment-wide error rates will therefore be less than 5 percent (Lubin Note 4).

RESULTS

The average within-person correlations between the mood measures are presented in Table 1. These mean correlations are highly significant and each reflects at least 8 significant ($p < .05$) individual correlations. Significant interindividual differences in the within-person correlations were observed for the following mood pairs: Activity with Fatigue ($V = 50.54$, $p < .027$), Anger with Happiness ($V = 58.13$, $p < .0045$), Fear ($V = 56.10$, $p < .0073$), and Depression ($V = 79.23$) $p < .0001$; Happiness with Fear ($V = 64.14$, $p < .0010$), Depression ($V = 58.75$, $p < .0038$), and Fatigue ($V = 50.42$, $p < .0268$); and Fear with Depression ($V = 122.97$, $p < .0001$) and Fatigue ($V = 49.08$, $p < .0355$).

[Insert Table 1 about here]

The average within-person correlations between the biochemical variables are presented in Table 2. Only 7 of 15 correlations are significant and all except that for cholesterol-uric acid ($r = .35$) were less than $r = .20$ in absolute magnitude. Five or more significant individual correlations were found for cholesterol with uric acid (9), uric acid with DBH (5) and pepsinogen (6), and DBH with pepsinogen (5). No V statistic was significant. Overall, these variables were generally independent.

[Insert Table 2 about here]

Table 3 presents the correlations between moods and biochemical measures. None of the correlations is greater than $r = .19$ in absolute value, but each of the biochemical variables shows at least one mean correlation that is significant.

[Insert Table 3 about here]

Table 4 presents the significant mood-biochemical correlations classified by whether or not they show any evidence of significant individual differences. Correlations in the first group may involve significant differences between individuals either because they showed a significant χ^2 significant, showed a greater than chance frequency of significant individual correlations (i.e., 5 or more), or showed both. A greater than chance frequency of significant individual correlations is a tentative basis for inferring individual differences as the significant correlations may prove replicable if the study were repeated, thereby identifying a subset of people with nonzero within-person correlations. Correlations in the second group did not satisfy either criterion for inferring significant differences between individuals.

[Insert Table 4 about here]

DISCUSSION

The primary research issue in this paper was whether moods and biochemical variables covaried when studied using a within-person design encompassing periods with known variation in stress levels. The answer was affirmative, but as previously found in other research (Doering, et al., 1975; Houser, 1978), the associations were modest. However, because moods tended to correlate with several independent elements of biochemical arousal, the cumulative impact of emotional factors may be more significant than the individual correlations indicated.

The modest average correlations between the moods and the biochemical variables would not be a critical disconfirmation of the hypothesis that moods link psychosocial stresses to physiological responses which leads to illness if some individuals showed strong correlations. These individuals might then form a group at high risk for psychosomatic illness due to either psychological factors such as defensive responses to stress (Vickers, 1979) or physiological factors such as genetic differences in stress sensitivity (Hamburg, Hamburg & Barchas, 1975). Even using lenient tests for the significance of the differences in the within-person correlations, the evidence for such differences was limited. However, some study participants did have pronounced within-person correlations for particular mood-biochemical variable pairs. In these instances, the associations might replicate if the study were repeated. If so, the interindividual differences in within-person correlations could be regarded as stable traits (Lubin, Note 5) which could be used to identify individuals at risk for psychosomatic illness. This possibility cannot be tested in the present study. Another potential means of verifying that the observed interindividual differences were not random variation about a common true correlation would be to show that the magnitude of the correlations was systematically related to stress tolerance variables. This possibility will be explored in a future paper.

The final research question concerning whether there were one-to-one relationships of moods to biochemical variables was answered in the negative. There was no instance in which a given biochemical variable was associated with a single mood. This finding is obviously affected by the fact that the moods were highly intercorrelated, making specificity of mood-biochemical

associations unlikely. In other situations or with different measures of moods, moods might be more highly differentiated and different results might be obtained.

All three conclusions reached above are affected by the fact that the present study used peripheral measures of arousal. Theories linking emotion and biochemical arousal generally assume that certain biochemicals affect the central nervous system (cf., McGeer & McGeer, 1980) or that physiological arousal requires interpretation to be the basis for an emotional appraisal (Schachter & Singer, 1962). In the first instance, peripheral measures are at best indirect indicators of central nervous system activity and are probably influenced by an interplay of several central biochemical factors, including some which have no connection to emotion. In the second instance, the peripheral arousal indices are more critical to the model of emotion, but still depend on situational and personality variables to translate them into emotions. In each case, there is no simple association to peripheral arousal and strong correlations cannot be expected. Furthermore, because central nervous system arousal can produce multiple peripheral effects, specificity of association between moods and peripheral arousal indicators would not be expected in the biochemical approach to emotion. In the cognitive approach, such specificity clearly would not be expected because peripheral arousal is subject to different interpretations by different people. It follows from these considerations that the use of more central measures of physiological arousal and the inclusion of appropriate situational and personality variables could modify the conclusions reached here.

The data also raised additional interesting points. While moods were highly correlated on the average, the magnitude of the correlations tended to vary across people. This variation implies that some individuals may have

relatively highly differentiated emotional perceptions while others show more of an "all or none" emotional response. These two types may show different patterns of mood-biochemical associations, so psychological measures which could identify differentiated individuals (e.g., measures of cognitive complexity) may be important in stress research. The high average within-person correlations also suggest that studies showing independent dimensions of moods (e.g., Radloff & Helmreich, 1968; Ryman, Biersner & La Rocco, 1974) may be heavily influenced by the use of cross-sectional designs which emphasize chronic individual differences rather than acute affective arousal (Kraemer, Note 1). Further, the results imply that it can be expected that Epstein's (1976) finding of differences in the within- and between-person factor structures for moods will prove to be a replicable phenomenon. An alternative explanation for the high degree of correlation between the moods is that the present study situation is extraordinary in its ability to elicit a strongly polarized, general affective arousal.

The relative independence among the biochemical variables is consistent both with prior within-person correlational analysis (Rubin, Rahe, Clark & Arthur, 1970) and prior between-person factor analyses (e.g., Rose, Poe & Mason, 1967; Ellertsen, Johnsen & Ursin, 1978) which suggest independence of hormonal measures. This independence underscores Mason's (1975) position that stress research should study patterns of physiological arousal. Idiosyncratic differences in the strength of response for particular biochemical measures, or the pattern of response, may be critical to understanding the onset of psychosomatic illnesses.

Overall, the findings from the current study indicated that there was an association between mood and biochemical responses to stress. Whether the

association would be sufficient to be a significant contributor to the development of illness is an open question, but the relatively widespread association makes it possible that this is the case. The present study did not provide strong evidence for the presence of individual differences in the strength of the association between mood and biochemical variables, but the results did not conclusively rule out this possibility. If such differences exist, significant within-person correlations such as those observed for some individuals in this study may single out individuals at increased risk for psychosomatic illnesses. Other aspects of the data underscore the need to employ stress research designs which consider patterns of physiological stress responses and psychological concepts which may influence differentiation of perceptions of stress and moods.

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Table 1. Average Within-Person Correlations Between Moods

	Act.	Ang.	Hap.	Fear	Dep.	Fat.
Activity						
Anger	-.36***					
Happiness	.68***	-.46***	-			
Fear	-.40***	.53***	-.50***	-		
Depression	-.42***	.73***	-.54***	.57***	-	
Fatigue	-.56***	.53***	-.45***	.49***	.59***	-

*** $p < .0033$ (Experiment-wide probability of Type I error less than 5 percent given the 15 correlations computed for all mood variable pairs)

Table 2. Average Within-Person Correlations Between Biochemical Variables

	Chol.	U.A.	DBH	Pep.	Tes.	Cor.
Cholesterol	-					
Uric Acid	.35***	-				
Dopamine-beta-hydroxylase	.10*	-.16***	-			
Pepsinogen	.06	-.12	.19***	-		
Testosterone	.13**	-.10*	.10	.08	-	
Cortisol	.12**	.04	.02	-.02	.05	-

* $p < .05$

** $p < .01$ (Experiment-wide probability of a Type I error less than 5 percent given the 5 correlations computed for a single biochemical)

*** $p < .0033$ (Experiment-wide probability of a Type I error less than 5 percent given the 15 correlations computed for all biochemical variable pairs)

Table 3. Average Within-Person Correlations Between Moods and Biochemical Variables

	Chol.	U.A.	D&H	Pep.	Tes.	Cor.
Activity	.06	-.12*	.15**	.18**	.13*	.02
Anger	-.13**	.04	-.18**	-.13**	-.03	.04
Happiness	.15	-.06	.15*	.15*	.17***	-.02
Fear	-.05	.12	-.11	-.19*	-.13**	.04
Depression	-.17***	-.01	-.11*	-.18**	-.14***	.13**
Fatigue	-.12*	.05	-.17***	-.18***	-.19***	.06

* $p < .05$ ** $p < .0083$ (Experiment-wide probability of a Type I error less than 5 percent given the 6 correlations computed for an individual mood or biochemical)*** $p < .0014$ (Experiment-wide probability of a Type I error less than 5 percent given the 36 correlations computed for all mood-biochemical pairings)

Table 4

Categories of Within-Person Correlations between Moods and Biochemical Variables
Determined by Possible Interindividual Differences in the Correlations

		\bar{r}	V	Number Significant
<u>Possible Differences Present^a:</u>				
Cholesterol	Happiness	.15	-	5 ($p < .026$)
Dopamine-Beta-Hydroxylase	Anger	-.18	-	7 ($p < .0003$)
	Happiness	.15	53.8 ($p < .013$)	6 ($p < .006$)
	Depression	-.11	-	5 ($p < .026$)
Pepsinogen	Activity	.18	-	6 ($p < .006$)
	Happiness	.15	50.9 ($p < .025$)	6 ($p < .006$)
	Fear	-.19	-	-
	Depression	-.18	54.6 ($p < .011$)	5 ($p < .026$)
	Fatigue	-.18	-	7 ($p < .0003$)
Testosterone	Happiness	.17	-	5 ($p < .026$)
<u>No Evidence for Differences:</u>				
Cholesterol	Anger	-.13	-	-
	Depression	-.17	-	-
	Fatigue	-.12	-	-
Uric Acid	Activity	-.12	-	-
Dopamine-Beta-Hydroxylase	Activity	.15	-	-
	Fatigue	-.17	-	-
Pepsinogen	Anger	-.13	-	-
Testosterone	Activity	.13	-	-
	Depression	-.14	-	-
	Fatigue	-.19	-	-
	Fear	-.13	-	-
Cortisol	Depression	.13	-	-

^aThe possible presence of significant interindividual differences is inferred if (a) the V statistic is significant indicating differences in the true underlying correlations, (b) the number of significant individual correlations is greater than chance suggesting that at least some individuals have significant correlations while others do not, or (c) both.

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20. Abstract (continued)

variables and mood-biochemical pairs. Significant inter-individual differences in the correlations were present for moods and possibly for mood-biochemical pairs. These results were consistent with current theories of emotion given peripheral biochemical measures. The cumulative effects of the mood-biochemical associations may be significant for behavior and health, because moods were related to a number of relatively independent biochemical parameters. Because important inter-individual differences in within-person correlations are still a possibility, the hypothesis of strong mood-biochemical variable covariation may apply to some people.

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